**FIGURE 1**

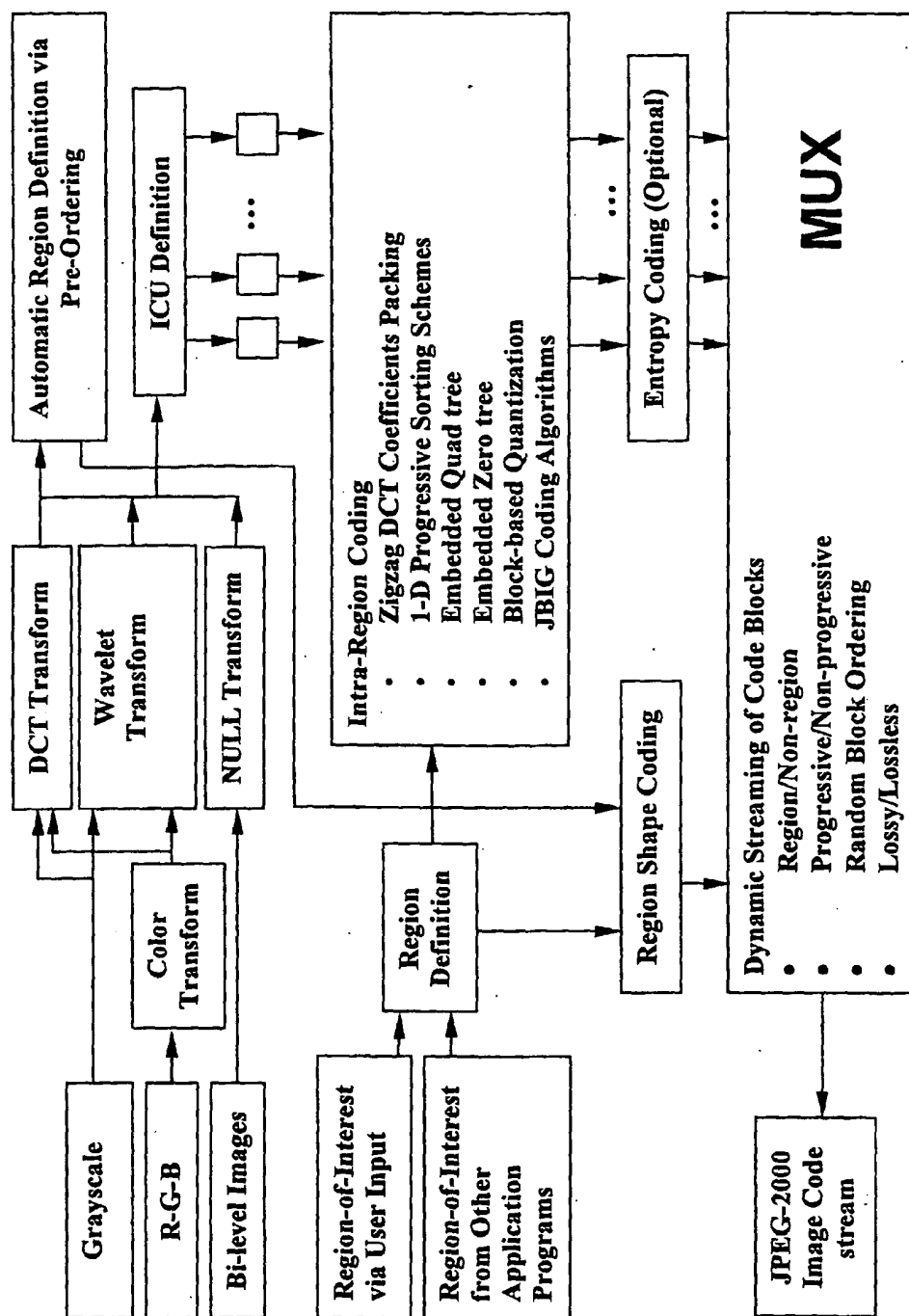


FIGURE 2

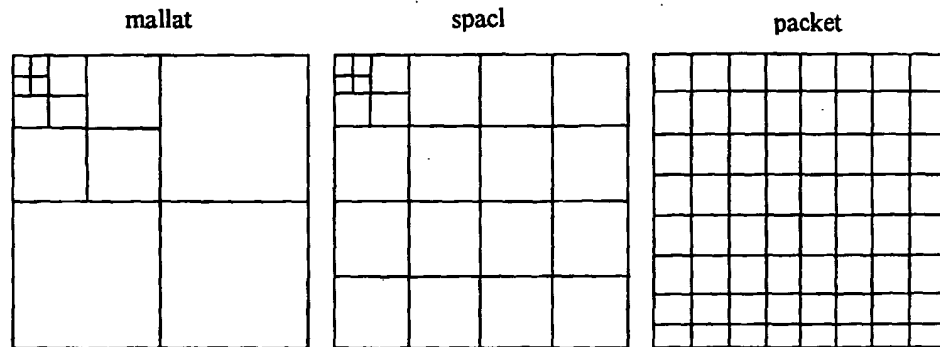


FIGURE 3

| Wavelet Family               | Wavelet Type ( Filter Length ) |                |                 |                |                |                |                 |                 |
|------------------------------|--------------------------------|----------------|-----------------|----------------|----------------|----------------|-----------------|-----------------|
| Haar                         | Haar<br>(2)                    |                |                 |                |                |                |                 |                 |
| Daubechies                   | Db4<br>(4)                     | Db6<br>(6)     | Db8<br>(8)      | Db10<br>(10)   | Db12<br>(12)   | Db14<br>(14)   | Db16<br>(16)    |                 |
| Coiflet                      | Coif1<br>(6)                   | Coif2<br>(12)  | Coif3<br>(18)   | Coif4<br>(24)  |                |                |                 |                 |
| Symmlet                      | Sym2<br>(4)                    | Sym3<br>(6)    | Sym4<br>(8)     | Sym5<br>(10)   | Sym6<br>(12)   | Sym7<br>(14)   | Sym8<br>(16)    |                 |
| Biorthogonal                 | Bior1.1<br>(2)                 | Bior1.3<br>(6) | Bior1.5<br>(10) | Bior2.2<br>(6) | Bior3.1<br>(4) | Bior3.3<br>(8) | Bior4.4<br>(10) | Bior5.5<br>(12) |
| Biorthogonal<br>(Villasenor) | Bior9<br>(10)9/7               | Bior10<br>(14) | Bior11<br>(10)  | Bior12<br>(6)  | Bior13<br>(6)  | Bior14<br>(10) | Bior15<br>10/18 |                 |

FIGURE 4

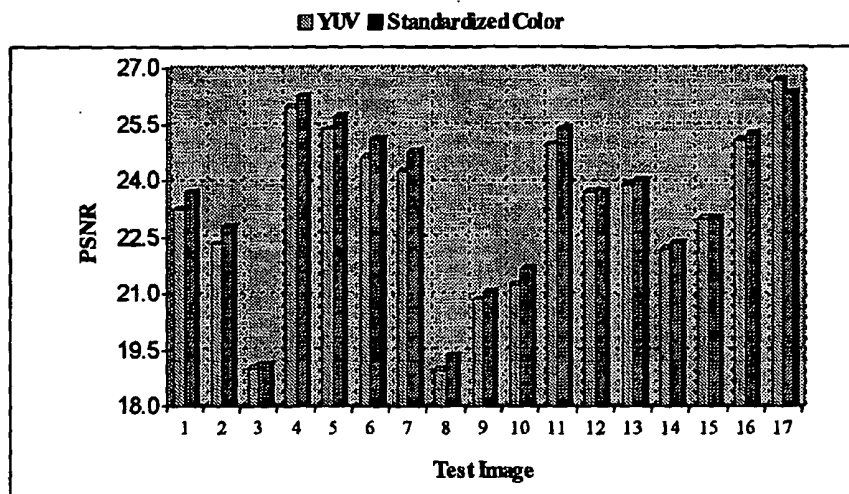


FIGURE 5

| Shape                   | Coding Parameters                                    | Availability in RICS |
|-------------------------|--|----------------------|
| Rectangle/Square        | $(x_{min}, y_{min})$ and <i>(width, height) etc.</i> | present              |
| Circle/Ellipse          | $(x_0, y_0)$ and <i>r etc.</i>                       | present              |
| Polygon                 | $n, (x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$         | Under development    |
| Cubic parametric curves | $n, (x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$         | Under development    |

FIGURE 6

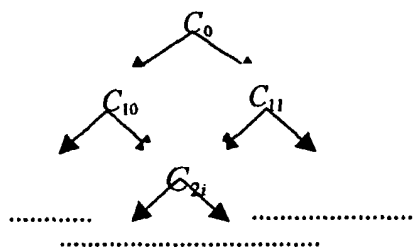


FIGURE 7

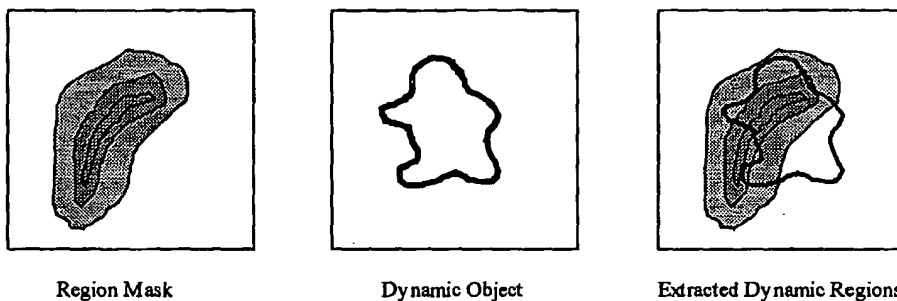


FIGURE 8

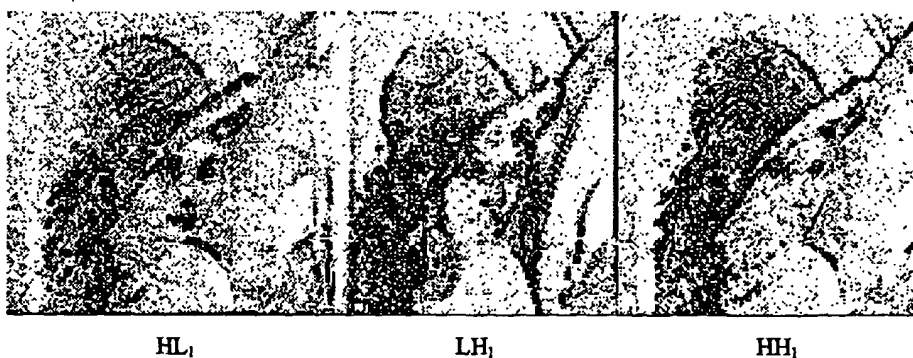
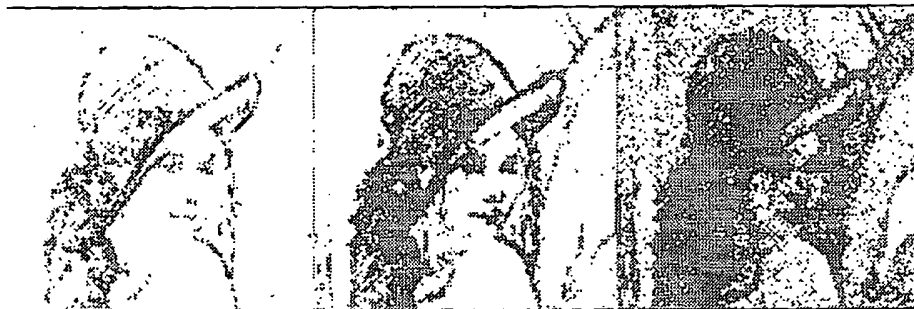


FIGURE 9



**FIGURE 10**

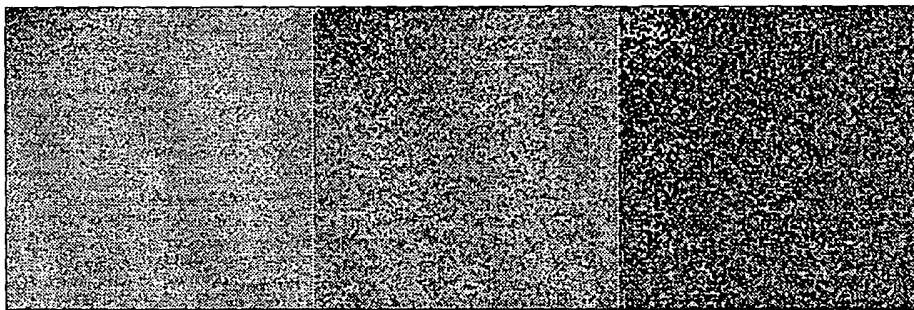


R1

R2

R3

**FIGURE 11**

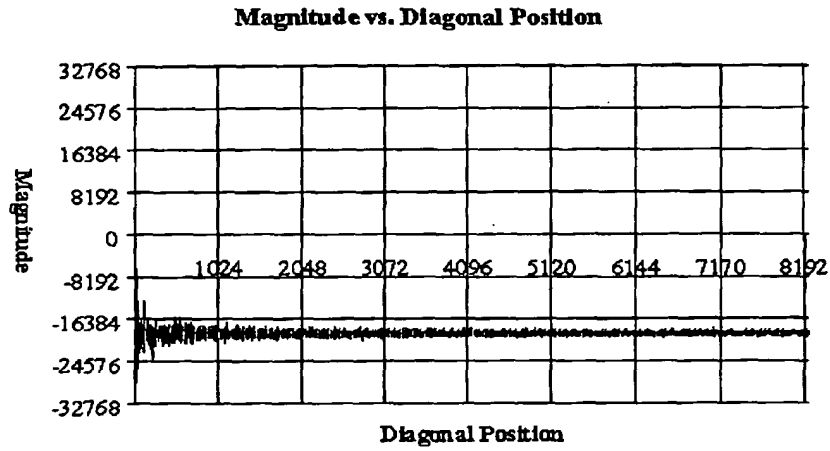


R1

R2

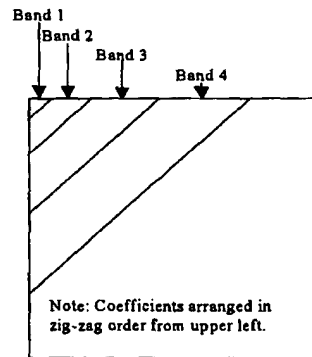
R3

**FIGURE 12**



| Common Mask Dimension | Spectral Filter Size | Included Spectral Coefficients |
|-----------------------|----------------------|--------------------------------|
| 32 x 32               | 32                   | 528                            |
| 64 x 64               | 38                   | 741                            |
| 128 x 128             | 44                   | 990                            |
| 256 x 256             | 52                   | 1378                           |
| 512 x 512             | 61                   | 1891                           |
| 1024 x 1024           | 71                   | 2556                           |

**FIGURE 14**



| Band | Diagonal Rows | Included Spectral Coefficients |
|------|---------------|--------------------------------|
| 1    | 3             | 6                              |
| 2    | 6             | 39                             |
| 3    | 12            | 186                            |
| 4    | 24            | 804                            |

FIGURE 16

| Mask Spectrum Size | Band 1 Rows | Band 2 Rows | Band 3 Rows | Band 4 Rows |
|--------------------|-------------|-------------|-------------|-------------|
| 32 x 32            | 1           | 2           | 4           | 8           |
| 64 x 64            | 2           | 4           | 8           | 16          |
| 128 x 128          | 3           | 6           | 12          | 24          |
| 256 x 256          | 4           | 8           | 16          | 32          |
| 512 x 512          | 5           | 10          | 20          | 40          |

FIGURE 17

| Image Size (pixels) | Image Size (bytes) | Mask Overhead (bytes) | Mask Overhead (%) |
|---------------------|--------------------|-----------------------|-------------------|
| 64 x 64             | 4096               | 546                   | 13.3              |
| 128 x 128           | 16384              | 764                   | 4.6               |
| 256 x 256           | 65536              | 1021                  | 1.6               |
| 512 x 512           | 262144             | 1420                  | 0.5               |
| 1024 x 1024         | 1048576            | 1948                  | 0.2               |

FIGURE 18





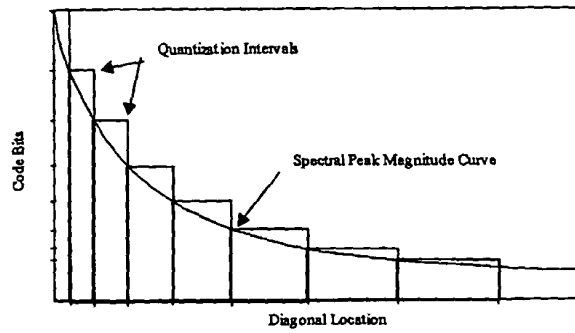


FIGURE 20



FIGURE 21

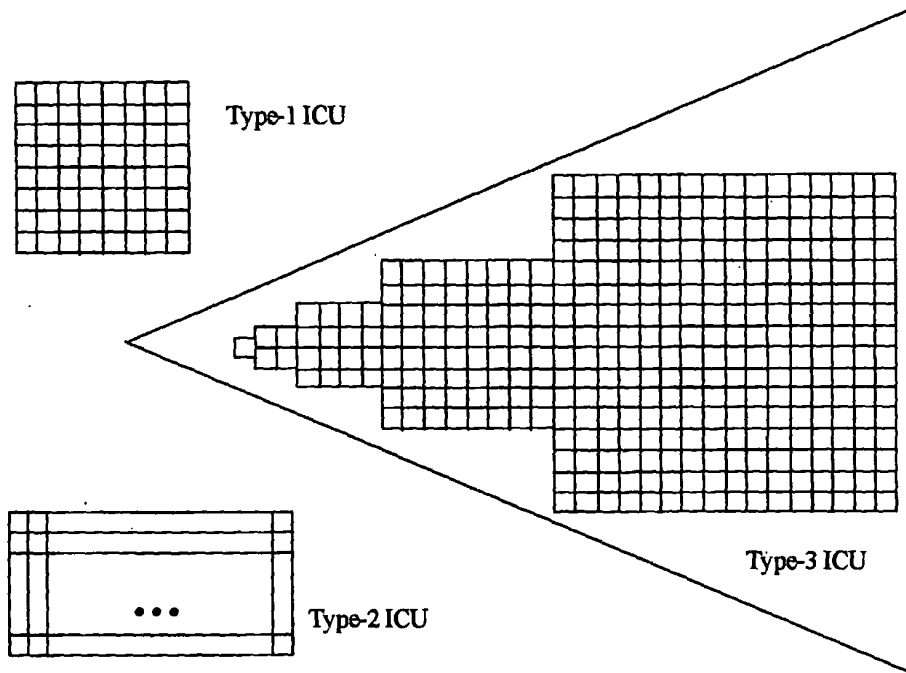


FIGURE 22

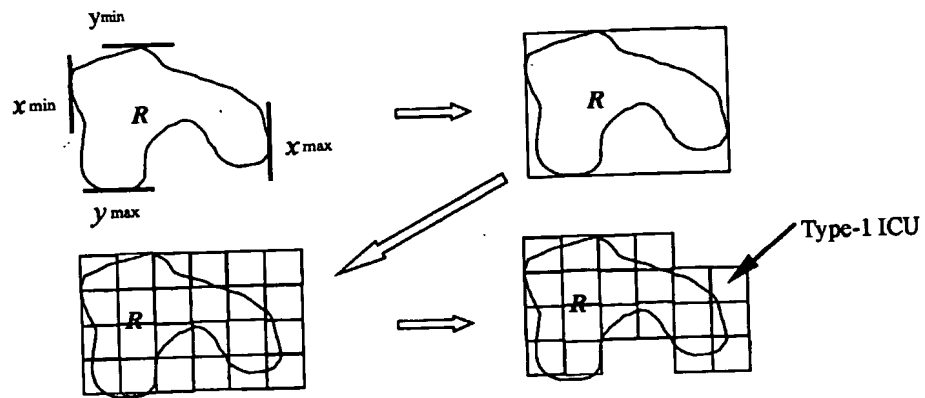


FIGURE 23

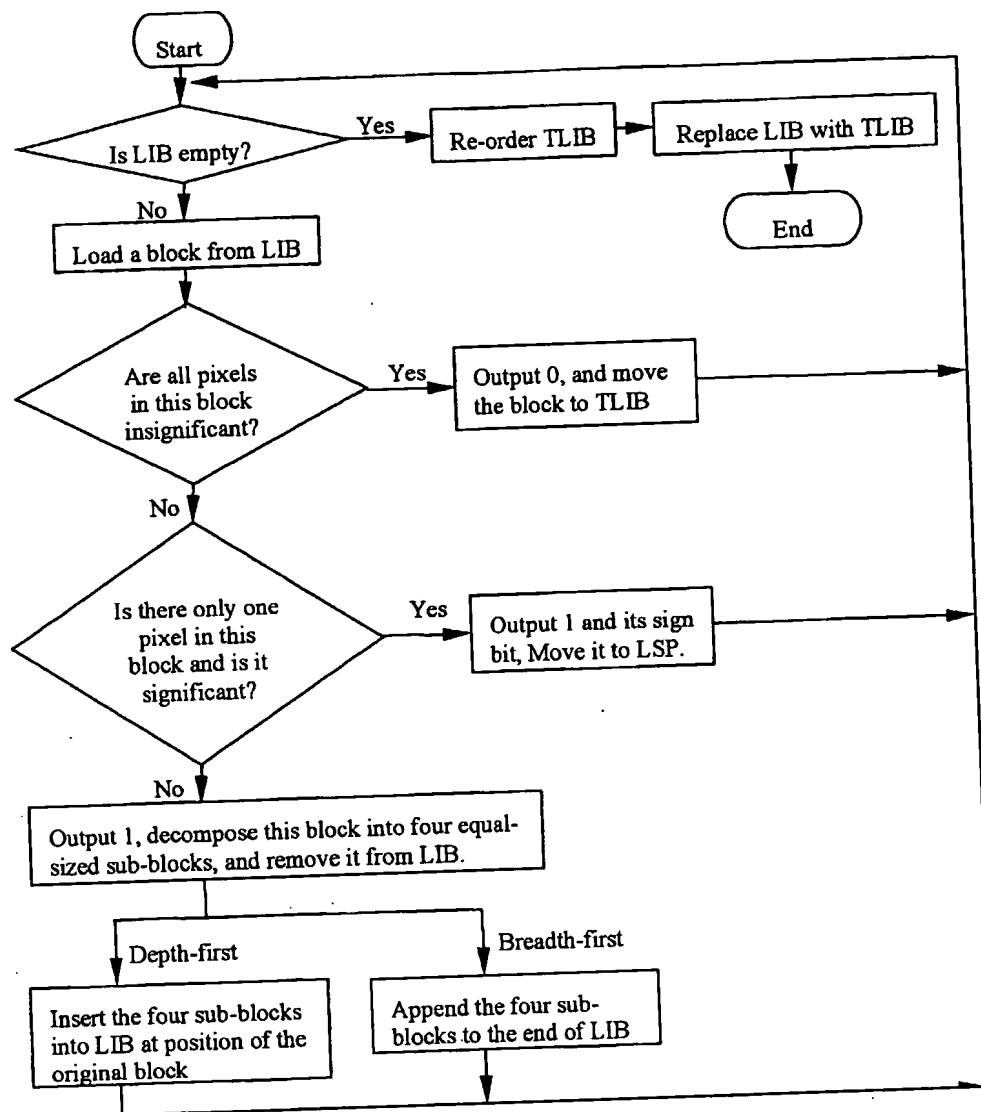


FIGURE 24

| For LL Subband |          | For Blocks of Size $n \times n$ ( $n > 2$ ) of Other Subbands |          | For Other Types of Blocks |          |
|----------------|----------|---|----------|---------------------------|----------|
| Sequence       | VLC Code | Sequence  | VLC Code | Sequence                  | VLC Code |
| 1111           | 000      | 0001  | 000      | 0001                      | 000      |
| 1010           | 001      | 0010  | 001      | 0010                      | 001      |
| 0101           | 010      | 0100  | 010      | 0100                      | 010      |
| 0100           | 011      | 1111  | 011      | 1000                      | 011      |
| 1110           | 1000     | 0011  | 1000     | 1100                      | 1000     |
| 1101           | 1001     | 1000  | 1001     | 1010                      | 1001     |
| 0111           | 1010     | 1100  | 1010     | 0101                      | 1010     |
| 0010           | 1011     | 1101  | 1011     | 0011                      | 1011     |
| 1100           | 11000    | 0101  | 11000    | 0110                      | 11000    |
| 1011           | 11001    | 0110  | 11001    | 0111                      | 11001    |
| 1001           | 11010    | 0111  | 11010    | 1001                      | 11010    |
| 1000           | 11011    | 1001  | 11011    | 1011                      | 11011    |
| 0110           | 11100    | 1010  | 11100    | 1101                      | 11100    |
| 0011           | 11101    | 1011  | 11101    | 1110                      | 11101    |
| 0001           | 11110    | 1110  | 11110    | 1111                      | 11110    |

FIGURE 25

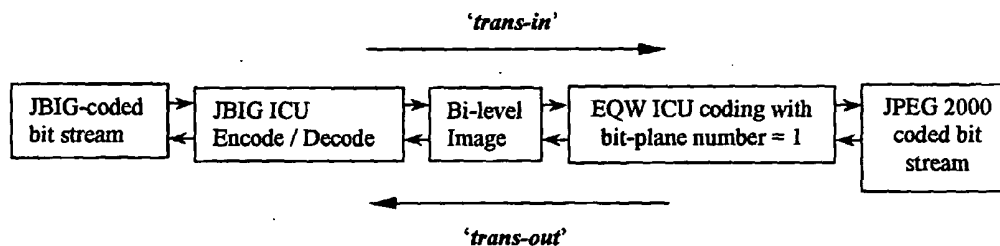


FIGURE 26

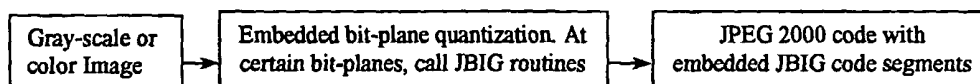


FIGURE 27

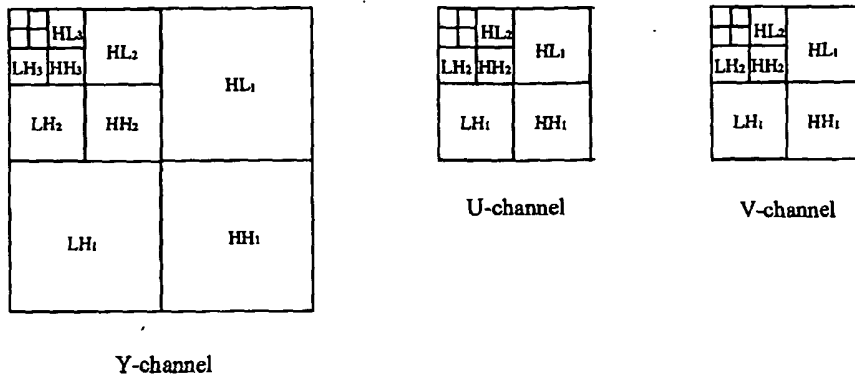


FIGURE 28

Y-channel: LL<sub>4</sub>-HL<sub>4</sub>-LH<sub>4</sub>-HH<sub>4</sub>-HL<sub>3</sub>-LH<sub>3</sub>-HH<sub>3</sub>-HL<sub>2</sub>-LH<sub>2</sub>-HH<sub>2</sub>-HL<sub>1</sub>-LH<sub>1</sub>-HH<sub>1</sub>  
 U-channel: LL<sub>3</sub>-HL<sub>3</sub>-LH<sub>3</sub>-HH<sub>3</sub>-HL<sub>2</sub>-LH<sub>2</sub>-HH<sub>2</sub>-HL<sub>1</sub>-LH<sub>1</sub>-HH<sub>1</sub>  
 V-channel: LL<sub>3</sub>-HL<sub>3</sub>-LH<sub>3</sub>-HH<sub>3</sub>-HL<sub>2</sub>-LH<sub>2</sub>-HH<sub>2</sub>-HL<sub>1</sub>-LH<sub>1</sub>-HH<sub>1</sub>

FIGURE 29

Y<sub>LL4</sub>-Y<sub>HL4</sub>-Y<sub>LH4</sub>-Y<sub>HH4</sub>-U<sub>LL3</sub>-V<sub>LL3</sub>-  
 Y<sub>HL3</sub>-Y<sub>LH3</sub>-Y<sub>HH3</sub>-U<sub>HL3</sub>-U<sub>HH3</sub>-V<sub>HL3</sub>-V<sub>HH3</sub>-  
 Y<sub>HL2</sub>-Y<sub>LH2</sub>-Y<sub>HH2</sub>-U<sub>HL2</sub>-U<sub>HH2</sub>-V<sub>HL2</sub>-V<sub>HH2</sub>-  
 Y<sub>HL1</sub>-Y<sub>LH1</sub>-Y<sub>HH1</sub>-U<sub>HL1</sub>-U<sub>HH1</sub>-V<sub>HL1</sub>-V<sub>HH1</sub>

FIGURE 30

Y<sub>LL4</sub>-Y<sub>HL4</sub>-Y<sub>LH4</sub>-Y<sub>HH4</sub>-U<sub>LL3</sub>-V<sub>LL3</sub>-  
 Y<sub>HL3</sub>-U<sub>HL3</sub>-V<sub>HL3</sub>-Y<sub>LH3</sub>-U<sub>LH3</sub>-V<sub>LH3</sub>-Y<sub>HH3</sub>-U<sub>HH3</sub>-V<sub>HH3</sub>-  
 Y<sub>HL2</sub>-U<sub>HL2</sub>-V<sub>HL2</sub>-Y<sub>LH2</sub>-U<sub>LH2</sub>-V<sub>LH2</sub>-Y<sub>HH2</sub>-U<sub>HH2</sub>-V<sub>HH2</sub>-  
 Y<sub>HL1</sub>-U<sub>HL1</sub>-V<sub>HL1</sub>-Y<sub>LH1</sub>-U<sub>LH1</sub>-V<sub>LH1</sub>-Y<sub>HH1</sub>-U<sub>HH1</sub>-V<sub>HH1</sub>

FIGURE 31

Y<sub>LL4</sub>-U<sub>LL4</sub>-V<sub>LL4</sub>-Y<sub>HL4</sub>-Y<sub>LH4</sub>-Y<sub>HH4</sub>-U<sub>HL4</sub>-U<sub>LH4</sub>-U<sub>HH4</sub>-V<sub>HL4</sub>-V<sub>LH4</sub>-V<sub>HH4</sub>-  
 Y<sub>HL3</sub>-Y<sub>LH3</sub>-Y<sub>HH3</sub>-U<sub>HL4</sub>-U<sub>LH4</sub>-U<sub>HH4</sub>-V<sub>HL3</sub>-V<sub>LH3</sub>-V<sub>HH3</sub>-  
 Y<sub>HL2</sub>-Y<sub>LH2</sub>-Y<sub>HH2</sub>-U<sub>HL2</sub>-U<sub>LH2</sub>-U<sub>HH2</sub>-V<sub>HL2</sub>-V<sub>LH2</sub>-V<sub>HH2</sub>-  
 Y<sub>HL1</sub>-Y<sub>LH1</sub>-Y<sub>HH1</sub>-U<sub>HL1</sub>-U<sub>LH1</sub>-U<sub>HH1</sub>-V<sub>HL1</sub>-V<sub>LH1</sub>-V<sub>HH1</sub>

FIGURE 32

$$\begin{aligned}
 &Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-U_{HL4}-V_{HL4}-Y_{LH4}-U_{LH4}-V_{LH4}-Y_{HH4}-U_{HH4}-V_{HH4} \\
 &Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3} \\
 &Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2} \\
 &Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}
 \end{aligned}$$

FIGURE 33

**Data Type: MUXLIST****Parameters:**

liTotBytesPacked - long integer total bytes packed into the data buffer for this list.  
 cScheme - character processing scheme used for data contained in this list.  
 cHighBit - character highest bit-level where data processing begins for this list.  
 \*pucMuxBuff - pointer to unsigned character buffer where data for each bit-level is packed for this list.

Fields for MUX: information for packing after list processing is complete.

pliBitPackInfo[16] - pointer to long integer number of bits packed into the data buffer at each bit-level for this list.  
 liCurBytesCount - long integer current byte count used for bit budget distribution when packing this list.  
 cCurBitLevel - character current bit-level used for packing this list.  
 cRemainingBits - character remaining bits to be packed at a given bit-level when data to be packed is not evenly divisible by 8 for this list.

FIGURE 34

```

CALCULATE Channel BitBudget // determine optimal bit-budget for each color channel.
INITIALIZE Channel CurrentBitPlane // highest bit plane that exists in each color channel.
INITIALIZE liCurBytesCount and cRemainingBits FOR each MUX list

FOR Each Color Channel // process each channel separately.
  WHILE Channel BitBudget > 0 AND Channel CurrentBitPlane >= 0
    FOR Each Wavelet Transform level // beginning at lowest resolution level.
      FOR Each Orientation Set of Data // according to lossy case natural processing order.
        IF cCurBitLevel NOT_EQUAL to Channel CurrentBitPlane
          CONTINUE
        ELSE
          SET BitLevelBytes to pliBitPackInfo[Channel CurrentBitPlane] >> 3
          SET RemBits to pliBitPackInfo[Channel CurrentBitPlane] & 7
          IF Sum(cRemainingBits, RemBits) >= 8
            INCREMENT BitLevelBytes by 1
            DECREMENT cRemainingBits by 8 - RemBits
          ELSE
            INCREMENT cRemainingBits by RemBits
          ENDIF
          IF Channel BitBudget >= BitLevelBytes
            INCREMENT liCurBytesCount by BitLevelBytes
            DECREMENT Channel BitBudget by BitLevelBytes
            DECREMENT cCurBitLevel by 1
          ELSE
            INCREMENT liCurBytesCount by Channel BitBudget
            SET Channel BitBudget to 0
          ENDIF
        ENDIF
      ENDIF
    END FOR
  END WHILE
  DECREMENT Channel CurBitPlane by 1
END FOR

```

FIGURE 35

| Orientation       | Max. Data Size (Bytes) | Req. Bits | Req. Bits for High Bit |
|-------------------|------------------------|-----------|------------------------|
| LL <sub>8</sub>   | 2x8 <sup>2</sup>       | 7         | 4                      |
| HL <sub>8</sub>   | 2x8 <sup>2</sup>       | 7         | 4                      |
| LH <sub>8</sub>   | 2x8 <sup>2</sup>       | 7         | 4                      |
| HH <sub>8</sub>   | 2x8 <sup>2</sup>       | 7         | 4                      |
| HL <sub>7</sub>   | 2x16 <sup>2</sup>      | 9         | 4                      |
| LH <sub>7</sub>   | 2x16 <sup>2</sup>      | 9         | 4                      |
| HH <sub>7</sub>   | 2x16 <sup>2</sup>      | 9         | 4                      |
| HL <sub>6</sub>   | 2x32 <sup>2</sup>      | 11        | 4                      |
| LH <sub>6</sub>   | 2x32 <sup>2</sup>      | 11        | 4                      |
| HH <sub>6</sub>   | 2x32 <sup>2</sup>      | 11        | 4                      |
| HL <sub>5</sub>   | 2x64 <sup>2</sup>      | 13        | 4                      |
| LH <sub>5</sub>   | 2x64 <sup>2</sup>      | 13        | 4                      |
| HH <sub>5</sub>   | 2x64 <sup>2</sup>      | 13        | 4                      |
| HL <sub>4</sub>   | 2x128 <sup>2</sup>     | 15        | 4                      |
| LH <sub>4</sub>   | 2x128 <sup>2</sup>     | 15        | 4                      |
| HH <sub>4</sub>   | 2x128 <sup>2</sup>     | 15        | 4                      |
| HL <sub>3</sub>   | 2x256 <sup>2</sup>     | 17        | 4                      |
| LH <sub>3</sub>   | 2x256 <sup>2</sup>     | 17        | 4                      |
| HH <sub>3</sub>   | 2x256 <sup>2</sup>     | 17        | 4                      |
| HL <sub>2</sub>   | 2x512 <sup>2</sup>     | 19        | 4                      |
| LH <sub>2</sub>   | 2x512 <sup>2</sup>     | 19        | 4                      |
| HH <sub>2</sub>   | 2x512 <sup>2</sup>     | 19        | 4                      |
| HL <sub>1</sub>   | 2x1024 <sup>2</sup>    | 21        | 4                      |
| LH <sub>1</sub>   | 2x1024 <sup>2</sup>    | 21        | 4                      |
| HH <sub>1</sub>   | 2x1024 <sup>2</sup>    | 21        | 4                      |
| Total Header Bits |                        | 343       | 100                    |

FIGURE 36



| Image Dimension<br>(Rows & Columns) | Overhead Bits<br>(Lossy) | Overhead Bits<br>(Lossless) | Overhead Bits<br>(GrayScale) |
|-------------------------------------|--------------------------|-----------------------------|------------------------------|
| 16                                  | 44                       | 132                         | 44                           |
| 32                                  | 171                      | 249                         | 83                           |
| 64                                  | 294                      | 384                         | 128                          |
| 128                                 | 435                      | 537                         | 179                          |
| 256                                 | 594                      | 708                         | 236                          |
| 512                                 | 771                      | 897                         | 299                          |
| 1024                                | 966                      | 1104                        | 368                          |
| 2048                                | 1179                     | 1329                        | 443                          |
| 4096                                | 1410                     | 1572                        | 525                          |
| 8192                                | 1659                     | 1833                        | 611                          |
| 16384                               | 1926                     | 2112                        | 704                          |
| 32768                               | 2211                     | 2409                        | 803                          |
| 65536                               | 2514                     | 2724                        | 908                          |

FIGURE 37

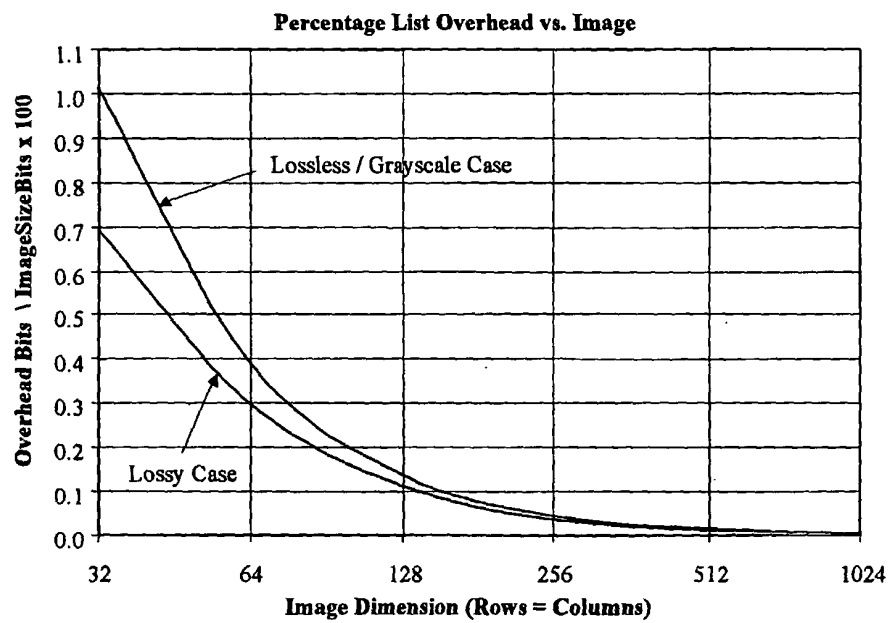


FIGURE 38

Y-channel:  $R_1(LL_4-HL_4-LH_4-HH_4-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_2(LL_4-HL_4-LH_4-HH_4-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_3(LL_4-HL_4-LH_4-HH_4-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_4(LL_4-HL_4-LH_4-HH_4-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ .

U-channel:  $R_1(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_2(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_3(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_4(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ .

V-channel:  $R_1(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_2(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_3(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ ,  
 $R_4(LL_3-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1)$ .

FIGURE 39

$R_1(Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-$   
 $Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}-$   
 $Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-$   
 $Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1})$ ,

$R_2(Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-$   
 $Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}-$   
 $Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-$   
 $Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1})$ ,

$R_3(Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-$   
 $Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}-$   
 $Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-$   
 $Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1})$ ,

$R_4(Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-$   
 $Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}-$   
 $Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-$   
 $Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1})$ .

FIGURE 40

$$\begin{aligned}
 R_1 & (Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}- \\
 & Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}- \\
 & Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}- \\
 & Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}), \\
 R_2 & (Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}- \\
 & Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}- \\
 & Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}- \\
 & Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}), \\
 R_3 & (Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}- \\
 & Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}- \\
 & Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}- \\
 & Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}), \\
 R_4 & (Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}- \\
 & Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}- \\
 & Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}- \\
 & Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}).
 \end{aligned}$$

FIGURE 41

$$\begin{aligned}
 R1 & (Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}- \\
 & Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 & Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 & Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}), \\
 R2 & (Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}- \\
 & Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 & Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 & Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}), \\
 R3 & (Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}- \\
 & Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 & Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 & Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}), \\
 R4 & (Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}- \\
 & Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 & Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 & Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}).
 \end{aligned}$$

FIGURE 42

$$\begin{aligned}
 & Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}- \\
 & Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 & Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 & Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1} \text{ (R1, R2, R3, R4).}
 \end{aligned}$$

FIGURE 43

$$\begin{aligned}
 &Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}- \\
 &Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}- \\
 &Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}- \\
 &Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1} \text{ (R1, R2, R3, R4)}
 \end{aligned}$$

FIGURE 44

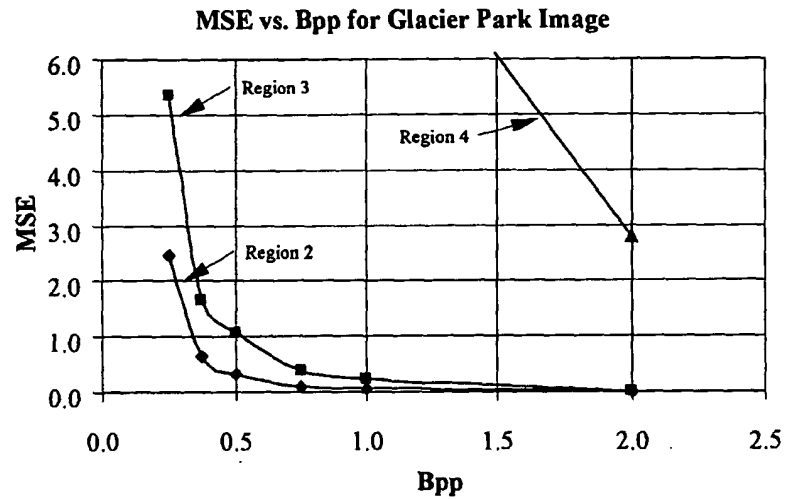


FIGURE 45

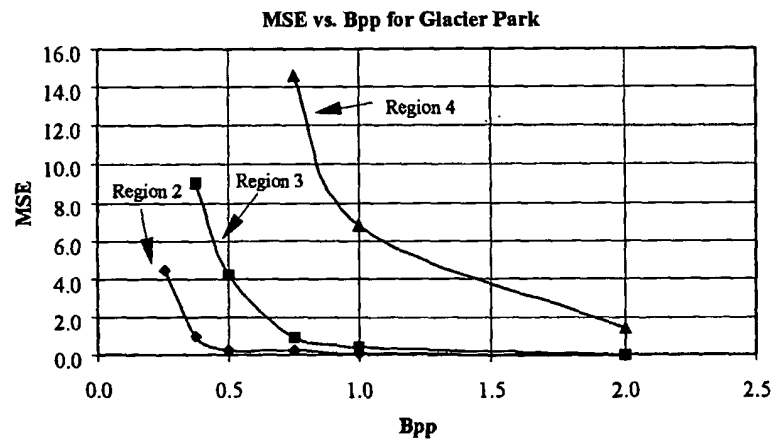
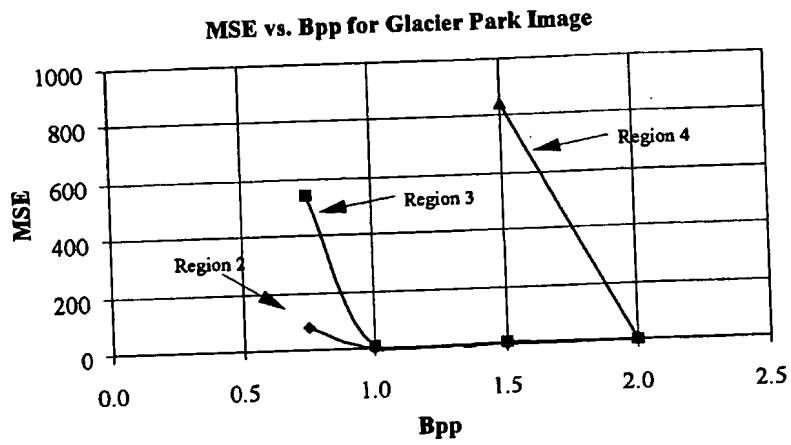
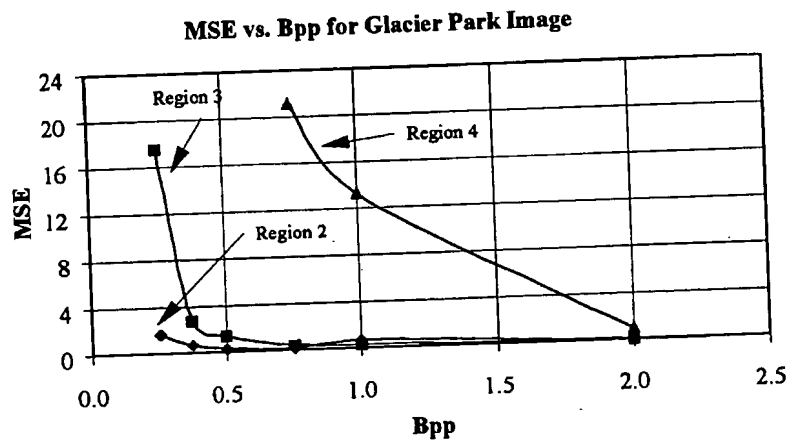


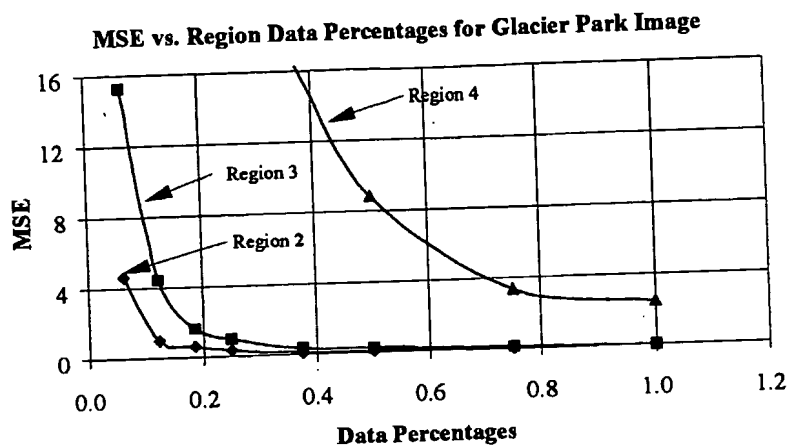
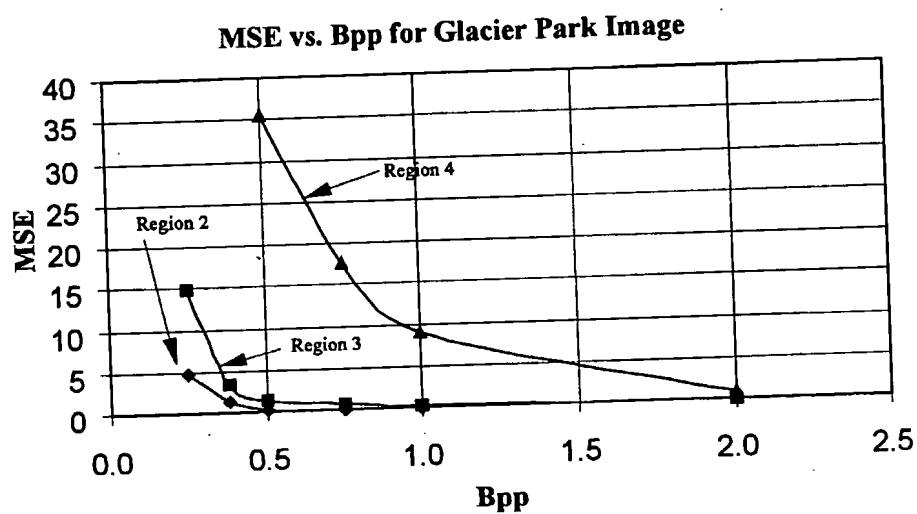
FIGURE 46



**FIGURE 47**



**FIGURE 48**

**FIGURE 49****FIGURE 50**

| Lossless Case                  |      |   |
|--------------------------------|------|---|
| Packed Item                    | bits | Selections / Comments                                 |
| header size                    | 8    | Total Header is normally about 6 bytes                |
| 8 bit grayscale / 24 bit color | 1    |   |
| Image Width                    | 10   | (64-1024 columns)                                     |
| Entropy Coding                 | 2    | None, Basic, Adaptive                                 |
| Image Height                   | 10   | (64-1024 rows)  |
| Wavelet Transform Levels       | 3    | Level $\geq 1$  |
| Region Channels                | 2    | 1, 2, 3, 4  |
| Mask Type                      | 2    | None, User, Auto (DCT)                                |
| Pack Raw Mask Flag             | 1    | Read in file for mask                                 |
| Mask Procedure                 | 3    | DCT Common Mask, Raw Common Mask with VM Translation, |
| Down Sampling Type             | 2    | Heuristic DCT Down Sampling                           |
| Region Start Level             | 4    | No Regions to # wavelet levels                        |
| Lossy Flag                     | 1    | Lossless  |
| Color Transform Type           | 2    | 2 Internal, YIQ (full data sets)                      |
| Sort Type                      | 1    | 1D, EQW   |
| Wavelet Kernel                 | 2    | Lifting Scheme  |

FIGURE 51

| Lossy Case                     |      |   |
|--------------------------------|------|---|
| Packed Item                    | bits | Selections  |
| header size                    | 8    | Between 6 to 12 bytes   |
| 8 bit grayscale / 24 bit color | 1    |   |
| Image Width                    | 10   | (64-1024)   |
| Image Height                   | 10   | (64-1024)   |
| Wavelet Transform Levels       | 3    | $L \geq 2$  |
| Region Channels                | 2    | 1, 2, 3, 4  |
| Mask Type                      | 2    | None, User, Auto (DCT)  |
| Pack Raw Mask Flag             | 1    | Read in file for mask   |
| Mask Procedure                 | 3    | DCT Common Mask, Raw Common Mask with VM Resolution Translation, User primitives Common or Full Size, User arbitrarily defined in Common and Full sizes |
| Down Sampling Type             | 2    | Heuristic DCT Down Sampling   |
| Region Start Level             | 4    | No Regions to #wavelet levels   |
| Lossy Flag                     | 1    | lossy   |
| Color Transform Type           | 2    | 2 Internal, KL, YIQ, YUV (down sampled data sets)   |
| Post Filter                    | 1    | Under Implementation  |
| Sort Type                      | 1    | 1D, EQW   |
| Wavelet Kernel                 | 3    | Daubachess, Symlet, Coiflet, Biorthogonal, Lifting Schemes  |
| Filter Type                    | 4    | Various common filter types/sizes   |
| KL Color Transform             | 48   | (if enabled)  |

FIGURE 52

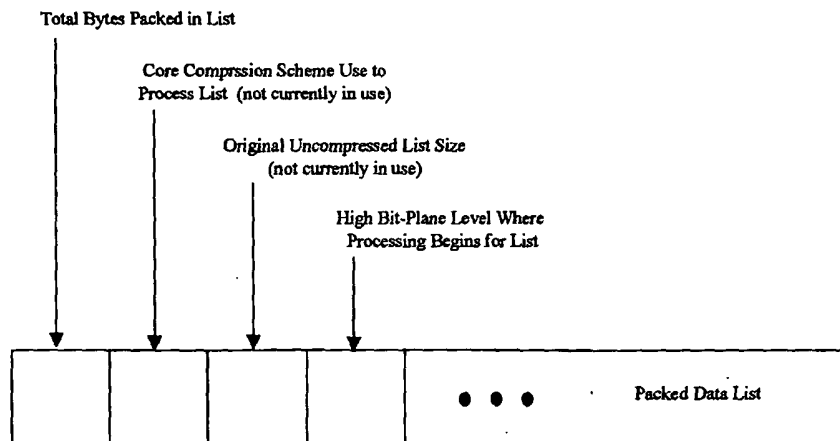


FIGURE 53



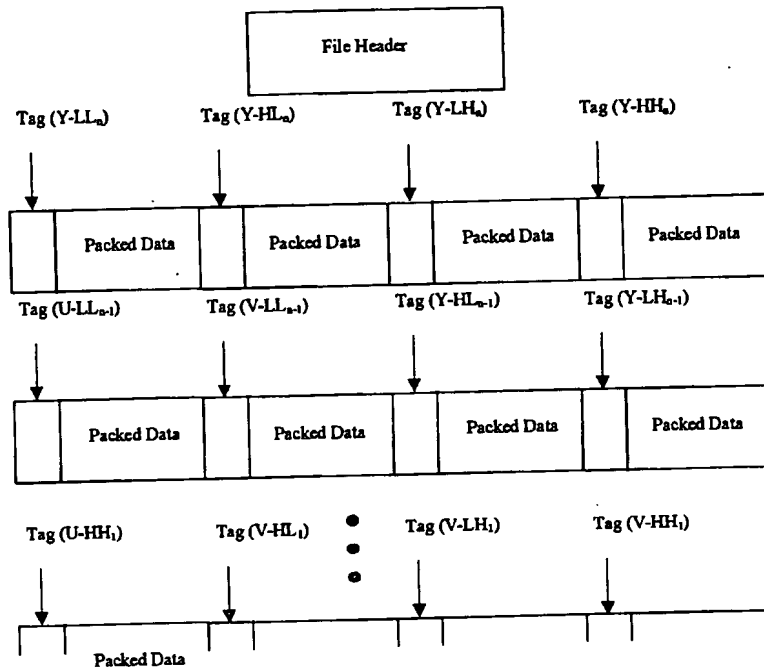


FIGURE 54

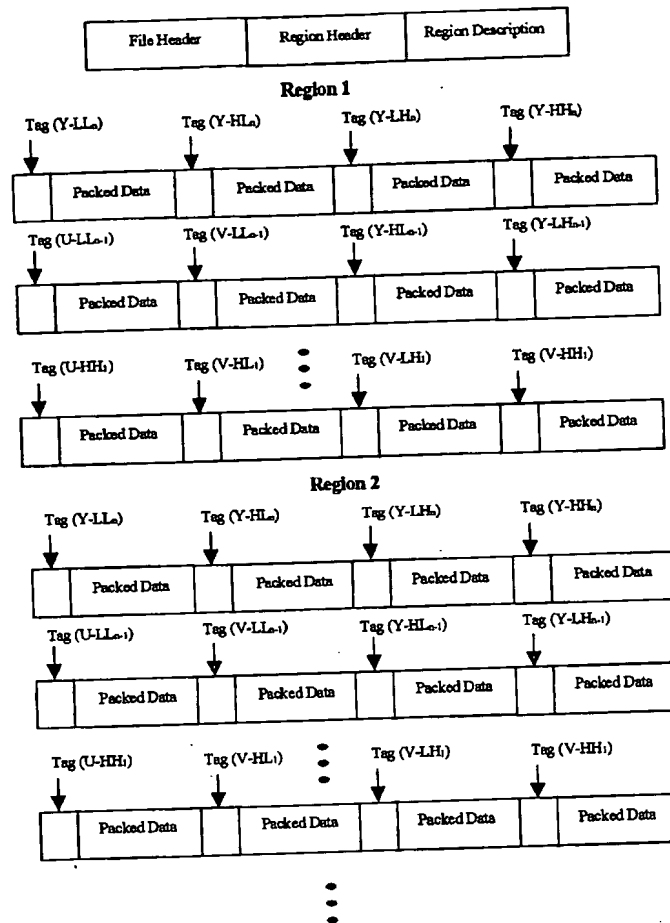


FIGURE 55

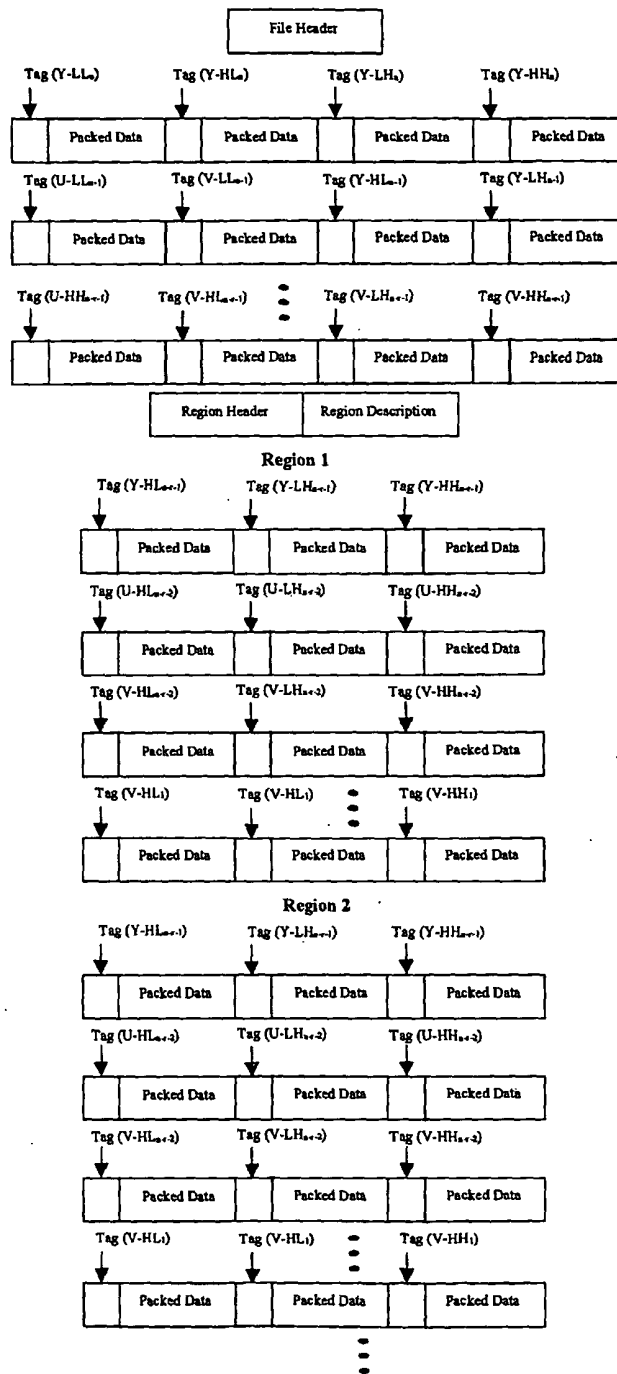


FIGURE 56

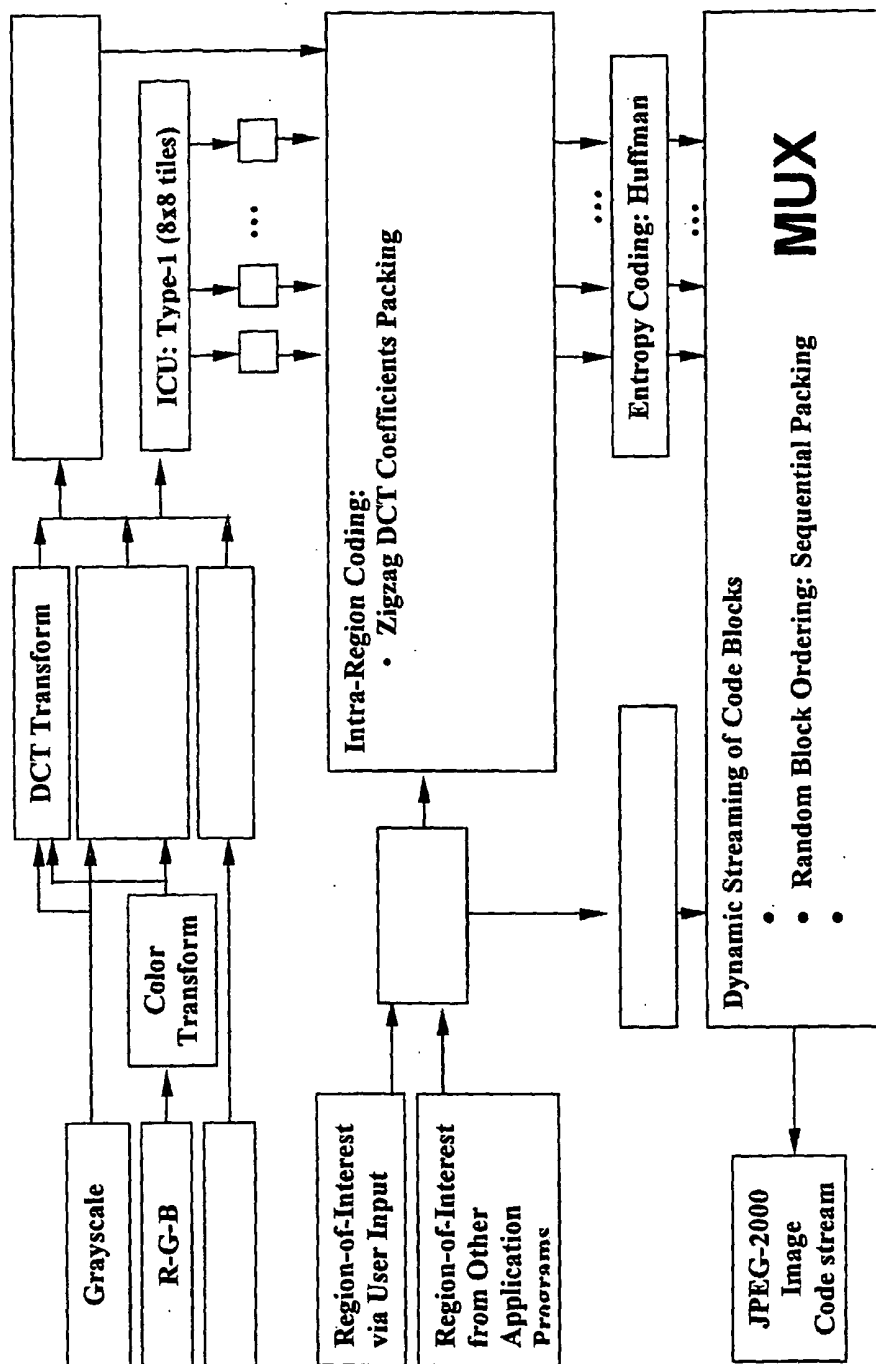


FIGURE 57

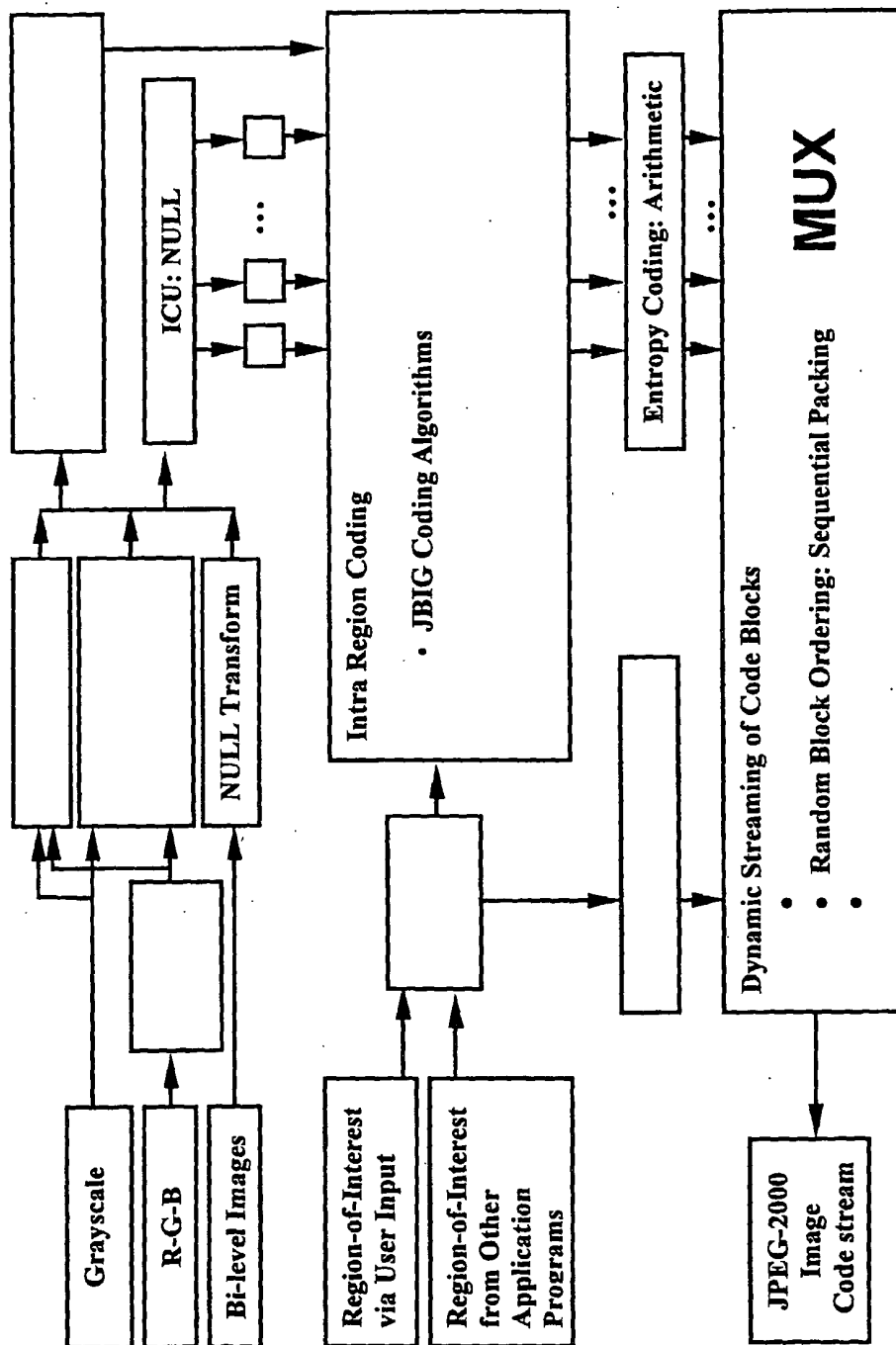
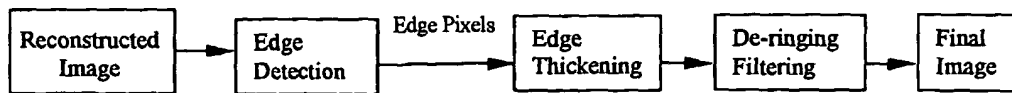
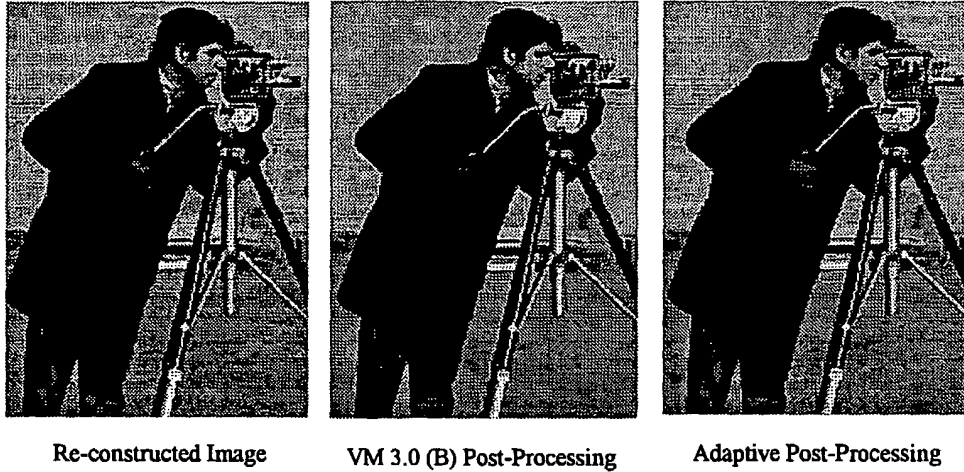


FIGURE 58

**FIGURE 59****FIGURE 60****FIGURE 61**

| Compression ratio | VM 3.0 (B) time (sec) | RICS Adaptive time (sec) | Compression ratio | VM 3.0 (B) time (sec) | RICS Adaptive time (sec) |
|-------------------|-----------------------|--------------------------|-------------------|-----------------------|--------------------------|
| 3.2170            | 7.310                 | 1.743                    | 3.709             | 22.392                | 5.398                    |
| 9.0140            | 7.260                 | 1.702                    | 8.889             | 23.023                | 8.151                    |
| 40.210            | 7.325                 | 1.482                    | 10.000            | 22.442                | 5.288                    |
| 48.763            | 7.170                 | 1.462                    | 11.428            | 22.232                | 5.809                    |
| 56.492            | 8.262                 | 1.402                    | 13.333            | 22.462                | 5.878                    |
| 66.550            | 8.703                 | 1.382                    | 16.000            | 22.482                | 5.629                    |
| 81.143            | 6.769                 | 1.362                    | 20.001            | 22.522                | 5.489                    |
| 103.716           | 7.171                 | 1.175                    | 26.666            | 22.382                | 5.568                    |
| 130.168           | 7.170                 | 1.222                    | 32.000            | 22.422                | 5.338                    |
| 169.019           | 8.310                 | 1.132                    | 40.002            | 22.352                | 3.896                    |
| 253.337           | 7.130                 | 1.052                    | 79.987            | 22.282                | 3.465                    |

FIGURE 62

| Compression Ratio | PSNR ( $\gamma=8$ ) | PSNR ( $\gamma=12$ ) | PSNR ( $\gamma=16$ ) |
|-------------------|---------------------|----------------------|----------------------|
| 3.709             | 31.329611           | 31.177579            | 30.511348            |
| 4.000             | 31.300452           | 31.154471            | 30.490295            |
| 5.333             | 31.157031           | 30.994670            | 30.357978            |
| 8.000             | 30.630383           | 30.474574            | 29.862022            |
| 8.889             | 30.401649           | 30.216825            | 29.646734            |
| 10.000            | 30.067778           | 29.909074            | 29.375402            |
| 11.428            | 29.691347           | 29.546710            | 29.056083            |
| 13.333            | 29.228454           | 29.103298            | 28.645196            |
| 16.000            | 28.407724           | 28.276664            | 27.908937            |
| 20.001            | 27.508670           | 27.413509            | 27.134810            |
| 26.666            | 26.385419           | 26.307257            | 26.084268            |
| 32.000            | 25.333808           | 25.280108            | 25.111808            |
| 40.002            | 24.696655           | 24.660851            | 24.509536            |
| 79.987            | 22.179274           | 22.152787            | 22.093103            |
| 100.004           | 21.592595           | 21.568550            | 21.525140            |

FIGURE 63

| Compression Ratio | PSNR (F=3) | PSNR (F=5) | PSNR (F=7) | PSNR (F=9) | PSNR (F=11) |
|-------------------|------------|------------|------------|------------|-------------|
| 1.583             | 35.514592  | 34.206867  | 33.687448  | 33.409849  | 33.223806   |
| 1.600             | 35.516204  | 34.201801  | 33.674565  | 33.408178  | 33.220934   |
| 2.000             | 35.314595  | 34.080237  | 33.538998  | 33.301232  | 33.090358   |
| 2.667             | 34.957612  | 33.765719  | 33.291270  | 33.011713  | 32.832969   |
| 4.000             | 34.002797  | 32.997735  | 32.564248  | 32.338257  | 32.200522   |
| 8.000             | 31.089735  | 30.554027  | 30.324381  | 30.196463  | 30.106473   |
| 8.889             | 30.572145  | 30.142348  | 29.935209  | 29.796335  | 29.725453   |
| 9.999             | 30.131952  | 29.795631  | 29.604549  | 29.472401  | 29.394763   |
| 11.429            | 29.629346  | 29.390456  | 29.261471  | 29.13131   | 29.064764   |
| 13.334            | 28.854873  | 28.701271  | 28.602145  | 28.527964  | 28.470308   |
| 16.000            | 27.870101  | 27.760478  | 27.671142  | 27.632609  | 27.579655   |
| 19.999            | 27.031806  | 26.910914  | 26.857123  | 26.835492  | 26.794267   |
| 26.662            | 25.962692  | 25.994100  | 25.999759  | 26.019787  | 25.991909   |
| 40.010            | 24.159134  | 24.178761  | 24.173011  | 24.191618  | 24.182049   |
| 80.020            | 21.654340  | 21.683920  | 21.731559  | 21.761676  | 21.774576   |

FIGURE 64

| Compression Ratio | PSNR (F=3) | PSNR (F=5) | PSNR (F=7) | PSNR (F=9) | PSNR (F=11) |
|-------------------|------------|------------|------------|------------|-------------|
| 3.709             | 31.656960  | 30.740420  | 30.806267  | 30.511348  | 30.298514   |
| 4.000             | 31.634763  | 30.735842  | 30.791791  | 30.490295  | 30.278695   |
| 5.333             | 31.436411  | 30.558898  | 30.635121  | 30.357978  | 30.141580   |
| 8.000             | 30.819587  | 30.065789  | 30.126713  | 29.862022  | 29.680912   |
| 8.889             | 30.537579  | 29.839074  | 29.879854  | 29.646734  | 29.474362   |
| 10.000            | 30.170406  | 29.541099  | 29.603527  | 29.375402  | 29.205815   |
| 11.428            | 29.740858  | 29.186726  | 29.255123  | 29.056083  | 28.880456   |
| 13.333            | 29.255225  | 28.752598  | 28.839294  | 28.645196  | 28.494299   |
| 16.000            | 28.391715  | 27.982943  | 28.075866  | 27.908937  | 27.788081   |
| 20.001            | 27.479117  | 27.162369  | 27.270921  | 27.134810  | 27.012976   |
| 26.666            | 26.329007  | 26.079132  | 26.175590  | 26.084268  | 25.999266   |
| 32.000            | 25.279960  | 25.088255  | 25.181387  | 25.111808  | 25.044080   |
| 40.002            | 24.649334  | 24.486896  | 24.568579  | 24.509536  | 24.446939   |
| 79.987            | 22.195351  | 22.099853  | 22.127757  | 22.093103  | 22.066329   |
| 100.004           | 21.598939  | 21.520845  | 21.561808  | 21.525140  | 21.501686   |

FIGURE 65



| Comp Ratio | MSE C4     | PSNR C4   | MSE C6     | PSNR C6   | MSE C8     | PSNR C8   | MSE C10    | PSNR C10  |
|------------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|
| 1.583      | 7.765411   | 39.229159 | 14.264114  | 36.588355 | 20.262634  | 35.063845 | 24.678070  | 34.207692 |
| 1.600      | 7.783203   | 39.219220 | 14.271622  | 36.586070 | 20.312759  | 35.053114 | 24.757339  | 34.193764 |
| 2.000      | 8.322881   | 38.925459 | 14.998596  | 36.370297 | 21.123337  | 34.883178 | 25.555661  | 34.055766 |
| 2.667      | 9.692001   | 38.266669 | 16.493225  | 35.957748 | 22.997864  | 34.513929 | 27.498306  | 33.737744 |
| 4.000      | 14.722046  | 36.451122 | 21.984375  | 34.709662 | 28.808853  | 33.535544 | 33.097488  | 32.932853 |
| 8.000      | 44.483109  | 31.648852 | 49.900986  | 31.149712 | 55.549133  | 30.684031 | 59.073853  | 30.416851 |
| 8.889      | 52.799194  | 30.904531 | 57.667984  | 30.521456 | 62.367477  | 30.181222 | 65.356079  | 29.977944 |
| 9.999      | 60.632019  | 30.303783 | 64.887344  | 30.009204 | 68.774963  | 29.756500 | 71.202606  | 29.605845 |
| 11.429     | 69.232758  | 29.727687 | 72.769318  | 29.511321 | 75.513184  | 29.350576 | 77.597488  | 29.232327 |
| 13.334     | 82.567825  | 28.962695 | 85.462585  | 28.813043 | 87.943863  | 28.688748 | 89.701675  | 28.602798 |
| 16.000     | 105.474950 | 27.899311 | 108.281906 | 27.785245 | 109.973099 | 27.717939 | 111.452667 | 27.659899 |
| 19.999     | 131.348300 | 26.946559 | 133.166946 | 26.886839 | 134.350037 | 26.848426 | 134.844223 | 26.832480 |
| 26.662     | 166.120390 | 25.926574 | 165.26181  | 25.949079 | 164.059326 | 25.980794 | 163.365967 | 25.999188 |
| 40.010     | 249.851910 | 24.153977 | 249.164856 | 24.165936 | 248.268158 | 24.181593 | 247.954636 | 24.187081 |
| 80.020     | 439.120450 | 21.704967 | 437.621460 | 21.719818 | 435.972107 | 21.736217 | 434.750366 | 21.748404 |

FIGURE 66

| Comp Ratio | MSE C12    | PSNR C12  | MSE C14    | PSNR C14  | MSE C16    | PSNR C16  |
|------------|------------|-----------|------------|-----------|------------|-----------|
| 1.583      | 29.654831  | 33.409849 | 33.271851  | 32.656521 | 41.355957  | 31.965423 |
| 1.600      | 29.666245  | 33.408178 | 33.268005  | 32.656995 | 41.379425  | 31.962959 |
| 2.000      | 30.405853  | 33.301232 | 36.249649  | 32.537766 | 42.367616  | 31.860463 |
| 2.667      | 32.501923  | 33.011713 | 38.265869  | 32.302688 | 43.982712  | 31.697984 |
| 4.000      | 37.933751  | 32.338257 | 43.370041  | 31.758905 | 48.739197  | 31.252020 |
| 8.000      | 62.148987  | 30.196463 | 65.897278  | 29.942129 | 69.077271  | 29.737452 |
| 8.889      | 68.147018  | 29.796335 | 70.858078  | 29.626910 | 73.573455  | 29.463474 |
| 9.999      | 73.424377  | 29.472401 | 75.836185  | 29.329176 | 78.898651  | 29.160108 |
| 11.429     | 79.423569  | 29.131310 | 81.619110  | 29.012885 | 84.361023  | 28.869385 |
| 13.334     | 91.260742  | 28.527964 | 93.193953  | 28.436833 | 95.293335  | 28.340178 |
| 16.000     | 112.155212 | 27.632609 | 113.068161 | 27.597400 | 114.424561 | 27.545611 |
| 19.999     | 134.750748 | 26.835492 | 135.182816 | 26.821589 | 135.73201  | 26.803981 |
| 26.662     | 162.592941 | 26.019787 | 162.853038 | 26.013378 | 163.141922 | 26.005148 |
| 40.010     | 247.695740 | 24.191618 | 248.170792 | 24.183297 | 249.198486 | 24.165350 |
| 80.020     | 433.423813 | 21.761676 | 433.733047 | 21.758578 | 434.813171 | 21.747777 |

FIGURE 67

| Comp Ratio | MSE C6     | PSNR C6   | MSE C8     | PSNR C8   | MSE C10    | PSNR C10  |
|------------|------------|-----------|------------|-----------|------------|-----------|
| 3.709      | 40.866048  | 32.017177 | 48.421931  | 31.280383 | 53.364817  | 30.858253 |
| 4.000      | 41.159272  | 31.988238 | 48.628245  | 31.261918 | 53.618078  | 30.837691 |
| 5.333      | 43.182419  | 31.777734 | 50.741887  | 31.077137 | 55.548584  | 30.684074 |
| 8.000      | 50.567968  | 31.092049 | 57.770162  | 30.513768 | 62.558919  | 30.167911 |
| 8.889      | 54.322167  | 30.781017 | 61.445058  | 30.245934 | 65.941528  | 29.939214 |
| 10.000     | 59.253784  | 30.403643 | 66.186651  | 29.923100 | 70.753092  | 29.633349 |
| 11.428     | 65.823083  | 29.947021 | 72.189621  | 29.546056 | 76.476232  | 29.295539 |
| 13.333     | 73.587957  | 29.462736 | 80.245789  | 29.086581 | 84.515152  | 28.861458 |
| 16.000     | 90.881770  | 28.546036 | 97.184072  | 28.254853 | 101.208043 | 28.078653 |
| 20.001     | 113.080653 | 27.596921 | 118.35673  | 27.398874 | 122.169271 | 27.261184 |
| 26.666     | 147.815740 | 26.433597 | 152.951072 | 26.285258 | 156.646398 | 26.181599 |
| 32.000     | 189.147156 | 25.362805 | 193.993169 | 25.252939 | 197.467316 | 25.175851 |
| 40.002     | 219.816732 | 24.710196 | 224.114268 | 24.626109 | 227.036153 | 24.569853 |
| 79.987     | 388.352183 | 22.238546 | 393.958450 | 22.176299 | 397.816293 | 22.133956 |
| 100.004    | 446.311579 | 21.634422 | 450.888418 | 21.590113 | 454.329178 | 21.557097 |

FIGURE 68

| Comp Ratio | PSNR R1   | PSNR R2   | PSNR R3   | PSNR R4   | PSNR R5   |
|------------|-----------|-----------|-----------|-----------|-----------|
| 1.583      | 36.574570 | 34.642943 | 33.409849 | 32.697519 | 32.241311 |
| 1.600      | 36.562052 | 34.637526 | 33.408178 | 32.690100 | 32.238019 |
| 2.000      | 36.362537 | 34.486701 | 33.301232 | 32.599597 | 32.146102 |
| 2.667      | 35.932465 | 34.134055 | 33.011713 | 32.347816 | 31.926978 |
| 4.000      | 34.722586 | 33.301598 | 32.338257 | 31.778517 | 31.416868 |
| 8.000      | 31.264379 | 30.640440 | 30.196463 | 29.892131 | 29.673122 |
| 8.889      | 30.660431 | 30.183697 | 29.796335 | 29.547117 | 29.365451 |
| 9.999      | 30.201141 | 29.800439 | 29.472401 | 29.244209 | 29.090109 |
| 11.429     | 29.706536 | 29.398255 | 29.131310 | 28.942109 | 28.805907 |
| 13.334     | 28.946950 | 28.733637 | 28.527964 | 28.378407 | 28.263955 |
| 16.000     | 27.924645 | 27.784119 | 27.632609 | 27.510373 | 27.424183 |
| 19.999     | 27.018210 | 26.938891 | 26.835492 | 26.749663 | 26.687918 |
| 26.662     | 26.025142 | 26.045564 | 26.019787 | 25.971153 | 25.921551 |
| 40.010     | 24.209514 | 24.214338 | 24.191618 | 24.152663 | 24.116273 |
| 80.020     | 21.70436  | 21.747276 | 21.761676 | 21.762267 | 21.751451 |

FIGURE 69

| Parameter            | Number of Bits | Value Range |
|----------------------|----------------|-------------|
| Mask Threshold       | 7              | 0-127       |
| Mask Width           | 4              | 5-20        |
| Estimation Threshold | 4              | 5-20        |
| Filter Length        | 3              | 3-10        |
| Constraints          | 4              | 3-18        |
| Iteration            | 2              | 1-4         |

**FIGURE 70**